ACTIVELY BALANCED MOBILE DRIVE UNIT

BACKGROUND

[0001] Modern inventory systems, such as those in mail order warehouses, supply chain distribution centers, airport luggage systems, and custom-order manufacturing facilities, face significant challenges in responding to requests for inventory items. As inventory systems grow, the challenges of simultaneously completing a large number of packing, storing, and other inventory-related tasks become non-trivial. In inventory systems tasked with responding to large numbers of diverse inventory requests, inefficient utilization of system resources, including space, equipment, and manpower, can result in lower throughput, unacceptably long response times, an ever-increasing backlog of unfinished tasks, and, in general, poor system performance. Additionally, as modern inventory systems continue to increase in size and complexity, any reduction in a number and/or cost of components utilized can result in a non-trivial cost savings when multiplied across a large number of units using those components within the inventory systems.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] Various embodiments in accordance with the present disclosure will be described with reference to the drawings, in which:

[0003] FIG. **1** illustrates an example of an inventory system that provides stable movement of inventory holders via actively balanced mobile drive units according to certain embodiments.

[0004] FIG. **2** illustrates components of an inventory system according to certain embodiments;

[0005] FIG. **3** illustrates in greater detail the components of an example management module that may be utilized in particular embodiments of the inventory system shown in FIG. **2**;

[0006] FIGS. **4** and **5** illustrate in greater detail an example of a mobile drive unit that may be utilized in particular embodiments of the inventory system shown in FIG. **2**;

[0007] FIGS. **6** and **7** illustrate an example of a mobile drive unit with an example of an arrangement of a sensor set that can be used to facilitate stable movement according to certain embodiments;

[0008] FIG. **8** illustrates in greater detail an example inventory holder that may be utilized in particular embodiments of the inventory system shown in FIG. **2**;

[0009] FIGS. **9-17** show operation of various components of an actively-balanced mobile drive unit and an inventory holder during docking, movement and undocking according to certain embodiments;

[0010] FIGS. **18-21** illustrate a kickstand that can be utilized on a mobile drive unit in various embodiments.

[0011] FIG. **22** illustrates another example of a mobile drive unit that can be used for stable movement according to certain embodiments;

[0012] FIG. **23** illustrates a block diagram of components of a mobile drive unit according to certain embodiments.

[0013] FIG. **24** is a flowchart illustrating an example of a process that can be performed with the components of FIG. **23** according to certain embodiments.

[0014] FIG. **25** illustrates an environment in which various features of the inventory system can be implemented, in accordance with at least one embodiment.

DETAILED DESCRIPTION

[0015] In the following description, various embodiments will be described. For purposes of explanation, specific configurations and details are set forth in order to provide a thorough understanding of the embodiments. However, it will also be apparent to one skilled in the art that the embodiments may be practiced without the specific details. Furthermore, well-known features may be omitted or simplified in order not to obscure the embodiment being described.

[0016] Embodiments herein are directed to an inventory system having multiple inventory holders and multiple mobile drive units for moving the inventory holders. Specific features are directed to stable movement of mobile drive units. The mobile drive units are configured to carry payloads, for example, an inventory holder (and any inventory, items, objects, containers, totes, or boxes stored therein) that the mobile drive unit has reached and lifted. The mobile drive unit accounts for characteristics of the payload and various forces acting on the payload and increases stability of the payload by changing motion parameters of elements of the mobile drive unit (e.g., driving a central pair of wheels of a mobile drive unit to bring an inventory holder carried by the mobile drive unit into a balanced state over the wheels). For example, a location of a center of gravity of the payload may be changed by adjusting the direction, velocity, and/or acceleration of wheels of the mobile drive unit carrying the inventory holder. Moving the location of the center of gravity of the payload closer to vertical alignment with a pivot point or axis of the mobile drive unit (e.g., closer to a position vertically over the axle of the mobile drive unit's wheels) may increase the stability of the payload, for example, in a stopped state. This may be because doing so balances moments acting on the payload, moving the payload toward a stopped equilibrium state. Maintaining the location of the center of gravity of the payload with respect to the pivot axis of the mobile drive unit (e.g., offset from the vertical alignment with the pivot axis that may be present in the stopped state) may maintain the stability of the payload in a travelling state. This may be because doing so balances moments acting on the payload, while moving the payload in a travelling equilibrium state. In some examples, moving the location of the center of gravity of the payload toward or away from alignment with the pivot axis can provide acceleration or motion of the payload that can facilitate transitioning the payload between stopped equilibrium and various travelling equilibrium states.

[0017] In various embodiments, the mobile drive unit includes a pivot axis, a sensing system, an inverted pendulum system, and a lifting system. The payload of the mobile drive unit can be rotatable about the pivot axis, which can permit the center of gravity of the payload to rotate about the pivot axis toward or away from a stopped equilibrium state. The stopped equilibrium state can correspond to a substantially stationary state in which moments acting on the center of gravity of the payload are balanced. For example, in the stopped equilibrium state, the center of gravity may be in a position in which the center of gravity is vertically aligned with respect to the pivot axis (e.g., vertically above the pivot axis in a stopped equilibrium state). The various travelling